men is 18½ inches, and the tail, 2 inches. It possesses four well-developed rattles and a single button, the entire length of the rattle being 15/32 inch.

The second specimen seen was considerably longer, measuring at least 2½ feet. In both cases they were found exposed to the sun, in the hummocks of *Juncus* and *Cypripedium hirsutum* in the marly areas of the swamp.

In July, another specimen was recorded by myself in the sphagnum areas of Featherbed Swamp, Spring Lake (near Auburn), N. Y.

Later in the summer, E. E. Honey and W. L. C. Muenscher of Cornell University reported having stepped on one, in Bergen Swamp.

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THE COLORS OF FISHES.

A friend of the writer, interested in the coloration of fishes, has asked that he place on record a sketch of his knowledge and interpretation of their coloration.

In discussing their colors, it is a convenience to divide fishes into several groups.

1. Free swimming fishes are those which spend the greater part of their lives moving actively about in the water not far from the surface, approaching the bottom or floating weed or other floating objects comparatively rarely or by chance.

2. Bottom and weed fishes are those which spend much of their lives near the bottom or close to or among floating weed and other objects.

3. Reef fishes are those which spend the greater part of their lives moving actively in the water, near, or among, the intricacies of tropical reefs.

4. Deep-water fishes are those found at considerable depths.

The colors of free-swimming fishes are mostly simple, white beneath, silvery on the sides, bluish, greenish or brownish above, sometimes more or less mottled (Mackerel).

The colors of bottom and weed fishes are more strongly, often intricately, marked, generally neutral in tone paler below.

The colors of reef fishes are the brightest, most contrasted, their markings often bold and bizarre.

Deep water fishes can not be so successfully generalized as to color, but among them we find three types which are sufficiently prevalent to be worthy of discussion, a red type, and one in which almost the entire fish is of a dark lustrous silver, at moderate depths; and a black type in greater depths.

In the free-swimming group there doubtless is a correspondence between the color of the upper parts of the fish, and that

of the water in which it swims. Some persons will claim that there is little variation in the color of water. Such, however, is not the writer's experience. The water of ponds and bays is variously brown; that of moderate depths on continental shelves (off New York, Newfoundland Banks, North Sea, between the Falkland Islands and South America), sea-green; that of the deep-sea in general (Gulf Stream, Trade-wind belts of all oceans, etc.), strong blue, etc. This color is what one sees by looking directly down into the water, not the surface color, due more or less to reflection, and which varies with weather conditions. Looked at at the proper angle in the right weather the deep sea and a muddy pond give the same bright blue surface color.

In general free-swimming fishes from brown waters are brownish above in life (Minnows); those from green waters, green; from blue waters, blue. There is a particularly close correspondence between the blue of certain off-shore fishes (Flying-fish, etc.) and that of the water in which they are found.

Conspicuousness is unquestionably a detriment to free-swimming fishes. They continually prey or are preyed upon by quick-sighted fishes or other creatures, often they both prey and are preyed on. Pretty surely their colors tend in the main to render them inconspicuous — the white of their underparts against the bright lower side of the sea surface, the brown, green or blue of their backs as the case may be, seen from above against the corresponding sea color. As compared with one of their number dead and lying on its back or side, their inconspicuousness often verges on the invisible. That their colors are always those that give them the lowest visibility is, however, not true. For instance, the adult dolphin is more or less bright yellow behind and below, just in that quarter where a fish is most open to attack. As a correlation we may note that the size and speed of the dolphin are such as to render it practically immune from attack, and that the yellow should enable these fish, which hunt wide stretches of blue water by sight in small schools, more readily to keep together. If one wished to paint a conspicuous mark in this blue water, yellow would perhaps be the best color to use.

The majority of species, certainly in temperate seas, belong to the second group of bottom or weed fishes. It is in this group that we find species whose colors match their surroundings so wonderfully that even the most sceptical naturalists will admit that they are protectively—that is, concealingly—colored. Notable examples are the gulf-weed fish, found only in the drifting gulf weed, and the flounders which lie on the bottom. The fact of concealing coloration here is obvious.

I am of the opinion that throughout this group the colors of the majority of the various species tend to conceal them, or

that they set limits to the conspicuousness of each. It is sometimes argued that when two species of animals with the same habits on the same territory are differently colored they cannot both be concealingly colored. In fact, this is a favorite formula with those who argue against wide existence of concealing colorations among animals. Its weakness as an argument is two-fold. First, the habits of no two species are exactly alike, or even those of the two sexes, or of the young and old. Second, concealing coloration is a relative matter. With a given environment and habits a single color and pattern very likely gives the lowest visibility, but several different colors and patterns may give a sufficiently low visibility for the needs of the animal.

Compared to those of group two, the boldly colored reef fishes (Group 3) have a high visibility. This statement is based on not inconsiderable personal observation, and agrees with the observations of most naturalists. The reefs and their agility enable them to flaunt with impunity colors which would be disastrous to other fishes.[1]

The colors of deep water fishes are the most puzzling, perhaps because we know least of the habits of this group and the conditions under which they live. In the deep shadows of the ocean depths lighted only by flashes of phosphorescence, the frequent black fishes would be expected to have a low visibility. The red species common in intermediate regions where little daylight penetrates would also have a low visibility, though conspicuous at the surface, because the light must penetrate so broad a belt of the green or blue water before reaching them. It is possible that a concealing value accounts for the black and the red. It is possible that the fish obtains physiological benefit from the absorption by its body of the faint light, an absorption facilitated by these colors. The silvery species differ from silvery surface fishes in the lack of white in the silver, and comparative absence of dark backs. Some of the Lantern fishes, small silvery, deep water species which come to the surface at night, have scales so burnished that the fish form almost perfect mirrors. They have a very low visibility at night.

Any naturalist with a wide experience of fishes in different habitats will, I think, see the force of the grouping presented above and agree in the main with the generalizations. Of course there are exceptions and special cases which it does not cover. There is a certain type of large-eyed, nocturnal red fish found on the reefs which one might readily class with the conspicuous diurnal species, some of which are red. Most of these nocturnal red fishes have red deep-water relatives, and an explanation of their color should rather be considered a problem corrolary to

[1] See Reighard, Pub. Tortugas Lab. Carnegie Inst., Wash., 2, 1908, 257-325. Nichols, Am. Mus. Journ., Dec., 1916, 507-511.

that of the red deep-water fish. Possibly it is a mere inheritance from deep-water ancestors. Then there are many fishes whose habitat and colors are intermediate between the different groups, or we find on the reefs bottom species, a variety of small blennies come to mind, adapted to the reef in habits and colors just as they and their relatives are to other types of bottom.

So far any mention of the great variation of color found within many species of fishes has been avoided. The males of many species assume high colors in the breeding season or when stimulated by breeding activities. My observations of such males are sufficient for me to conclude that in some species they have a higher visibility than when in normal more neutral color, and I assume that this is ordinarily the case. It is safe to assume also that an explanation of the high colors of such males should be homologous with that of the more permanent high colors found in the plumage of many male birds. The Darwinian hypothesis of sexual selection is so far the most satisfactory explanation of the phenomenon, though from some aspects an unsatisfactory explanation, at least in its unmodified form.

Extensive, rapid, color and pattern changes in individual flounders have been experimentally proved to be an adaptation for concealment, rendering the fish equally inconspicuous on various bottoms.

Fishes from the white bottoms near Key West I have found, as a rule, to harmonize in general color with the tone of the bottom, individuals from here being often very much whiter than those of the same species taken elsewhere on darker bottoms. From these considerations I would expect many color changes undergone by individual bottom and weed fishes to be correlated with concealment. Observations, particularly in aquaria, prove that there are color changes correlated with the fish's mental or physiological condition and apparently with no other bearing.

Many fishes undergo considerable color change with age. For instance, the young of the dolphin which hides about weed and other drift has a dull mottled color quite unlike that of the free-swimming adult, young and old belonging to quite different groups, according to my classification, and with colors correspondingly different.

In many, not all, of the boldly colored reef fishes individuals undergo considerable and rapid changes of color. Prof. Longley finds that the Red Parrotfish, *Sparisoma abildgaardi*,[2] (which I believe to be a typical reef fish, usually conspicuous, though my experience with the species in life is limited) has gray and brown probably concealing phases, and it is not unlikely that other ordinarily conspicuous reef fishes may have the same, which they assume especially when venturing away from the reef.

[2] Longley, Journ. Exp. Zool., 23, 1917, 547.

Recently a great deal has been written about the coloration of animals by persons differing as widely in temperament and training as the poles. So much of it is contradictory, that it must be confusing to a student of the subject who has not a good many correlated observations of his own by which to gage it. To such a one, however, it is almost all of interest, he never can tell where he will find an idea or an observed fact that will modify or clarify his own views. The storm center of discussion of late seems to have been as to the universality of concealing coloration. The Thayers,[3] with their artist's training in color values, have shown how concealing coloration may be and probably is more widely existant than it at first thought appears. Roosevelt[4] has called attention to how exaggerated some of their claims are —and so it goes. It is not the writer's purpose here to enter the discussion beyond sketching the facts with which he is familiar and indicating the manner in which he interprets them.

The most reasonable hypothesis seems to be that on a "background" of inheritance modified by physiological considerations, an animal's colors are generally useful to it in one or more of many ways. In a limited number of cases every other color tendency is subordinate to concealment, in a vastly greater number of cases its colors give it a low visibility, set limits to its conspicuousness. Often conspicuous colors, for warning, recognition or some other benefit may be present, interfering sometimes little, sometimes greatly with the tendency to inconspicuousness. The white outer tail-feathers of the meadowlark (to take a case from birds) as against the black plumage of the Grackle. It is even possible that the black plumage of the Grackle has a vestigeal concealing value, a white species of Grackle, though no more conspicuous ordinarily, might attract detrimental attention on its nest in the dark shadows of the pine top, where the black has low visibility. There is little to be gained by dragging the theory of natural selection into the discussion in its present stage. There is no doubt that it will explain concealing, warning, directive, etc., coloration satisfactorily, the question is not can they be explained, but to what extent do they exist.

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[3] See Thayer (G. H. & A. H.), Concealing Coloration in the Animal Kingdom, 1909.

[4] See Roosevelt, Bull. Am. Mus. Nat. Hist., 30, 1911, 119-231. Am. Mus. Journ., March, 1918, 211-218.

Edited by J. T. NICHOLS, American Museum of Natural History

PRICE FIVE CENTS